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STUDIES OF LAKE MICHIGAN BOTTOM SEDIMENTS—NUMBER THREE

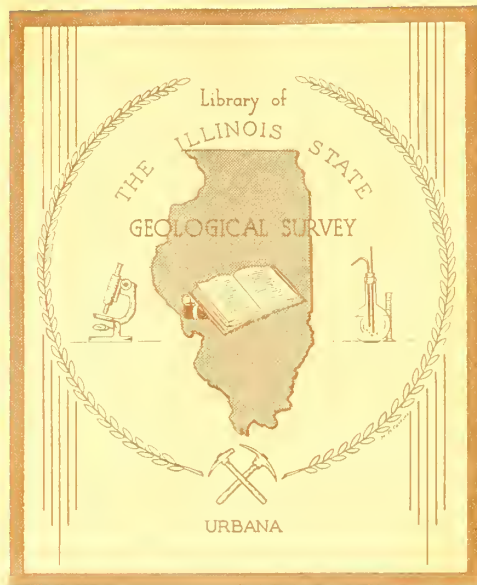
STRATIGRAPHY OF UNCONSOLIDATED
SEDIMENTS IN THE SOUTHERN PART
OF LAKE MICHIGAN

J. A. Lineback, N. J. Ayer, and D. L. Gross

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ILLINOIS STATE GEOLOGICAL SURVEY

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J. A. Lineback, N. J. Ayer, and D. L. Gross

ABSTRACT

Unconsolidated sediments of late Pleistocene age in southern Lake Michigan can be divided into two major lithologic units. The upper unit is dominantly lacustrine clay of high water content that is soft and variably fossiliferous. The lower unit consists of compact sandy sediments of glacial origin.

The upper unit is assigned to the Lake Michigan Formation and was deposited after the direct influence of the last glacier was felt in southern Lake Michigan. The Lake Michigan Formation is herein divided into six members and one bed on the basis of color, water content, cohesiveness, grain size, and mineralogy. The Ravinia Member contains the beach sands of the modern lake. The Waukegan Member (new) consists of dark gray to dark brown sandy silt to silty clay, sand, and gravel and is the surficial unit over most of the lake bottom. The Lake Forest Member (new) contains dark gray silty clay with many black beds. Dark brownish gray clay, also with black beds, is assigned to the Winnetka Member (new). The last three members are dominantly dark colored and their black beds and black mottling are usually absent from the predominantly light-colored units below. Most of the Sheboygan Member (new) is reddish brown clay, but it contains a persistent thin dark gray clay bed named the Wilmette Bed (new). The lowest member, the South Haven (new), consists of reddish gray clay.

Underlying the Lake Michigan Formation is a series of glacial-lacustrine deposits, including sand, sandy pebbly clay, silt, and clay-pebble conglomerate. These deposits are more compact, coarser grained, and contain less water than those of the Lake Michigan Formation. They show the direct effect of nearby glaciers. The glacial-lacustrine deposits are assigned to the Carmi Member of the Equality Formation and overlies glacial tills that are assigned to the Wadsworth Member of the Wedron Formation.

INTRODUCTION

Twenty-two cores 47 mm in diameter were taken from bottom sediments of southern Lake Michigan during September 1969 from the University of Michigan

Great Lakes Research Division's research vessel INLAND SEAS (fig. 1). Sediment recovered from the cores ranged from 19 to 361 cm thick. The samples are gravity cores, taken by the method described by Gross et al. (1970a, p. 7), and were refrigerated at 5° C until they were taken from the plastic core liners. Parts of several of the cores were frozen for chemical analysis and radiocarbon dating. The cores were subjected to X-ray radiography before they were opened. They were then extruded from the core liners, described in detail, photographed in color, and sampled for various purposes. Water content, grain size, and mineralogy were determined in the laboratories of the Illinois State Geological Survey under the direction of W. Arthur White.

The stratigraphy and nomenclature of the unconsolidated sediments from the 22 cores are discussed in this report. Six cores previously described by Gross et al. (1970a) are included in the discussion.

Acknowledgments

We are indebted to the University of Michigan Great Lakes Research Division and to Captain Thibault and the crew of the R. V. INLAND SEAS for their help in taking the cores. We also greatly appreciate the advice and assistance of Dr. H. V. Leland, Assistant Professor of Environmental Biology and Zoology at the University of Illinois, who was the chief scientist for the 1969 sampling expeditions.

STRATIGRAPHY

Sediments in southeastern Lake Michigan consist of lacustrine clays, glacial-lacustrine sediments, sand, gravel, and till. The sediments can be divided into two major lithologic units (fig. 2). The uppermost unit consists of soft, water-saturated, variably fossiliferous lacustrine silts and clays deposited in Lake Michigan after direct glacial influence had ceased. The lower unit contains various sediments that show the direct influence of the glaciers, including sand, pebbly clay and silt, clay-pebble conglomerate, and till.

The lacustrine sediments of the upper unit have been named the Lake Michigan Formation by Willman and Frye (1970) (fig. 2). The Lake Michigan Formation is of late Wisconsinan and Holocene age. It is sandy in nearshore areas, and the sandy beaches of the lake have been assigned to the Ravinia Sand Member of the Lake Michigan Formation by Willman and Frye (1970). As no specific core has previously been designated as a type section of the Lake Michigan Formation, core 143 is here designated the type section, and cores 118, 145, and 151 (see Core Descriptions in Appendix) are designated as reference sections. The Lake Michigan Formation ranges from 16 to more than 360 cm thick in the cores taken. It may be absent in places where bedrock or glacial deposits are exposed on the lake bottom. In some areas the cores did not penetrate the base of the formation.

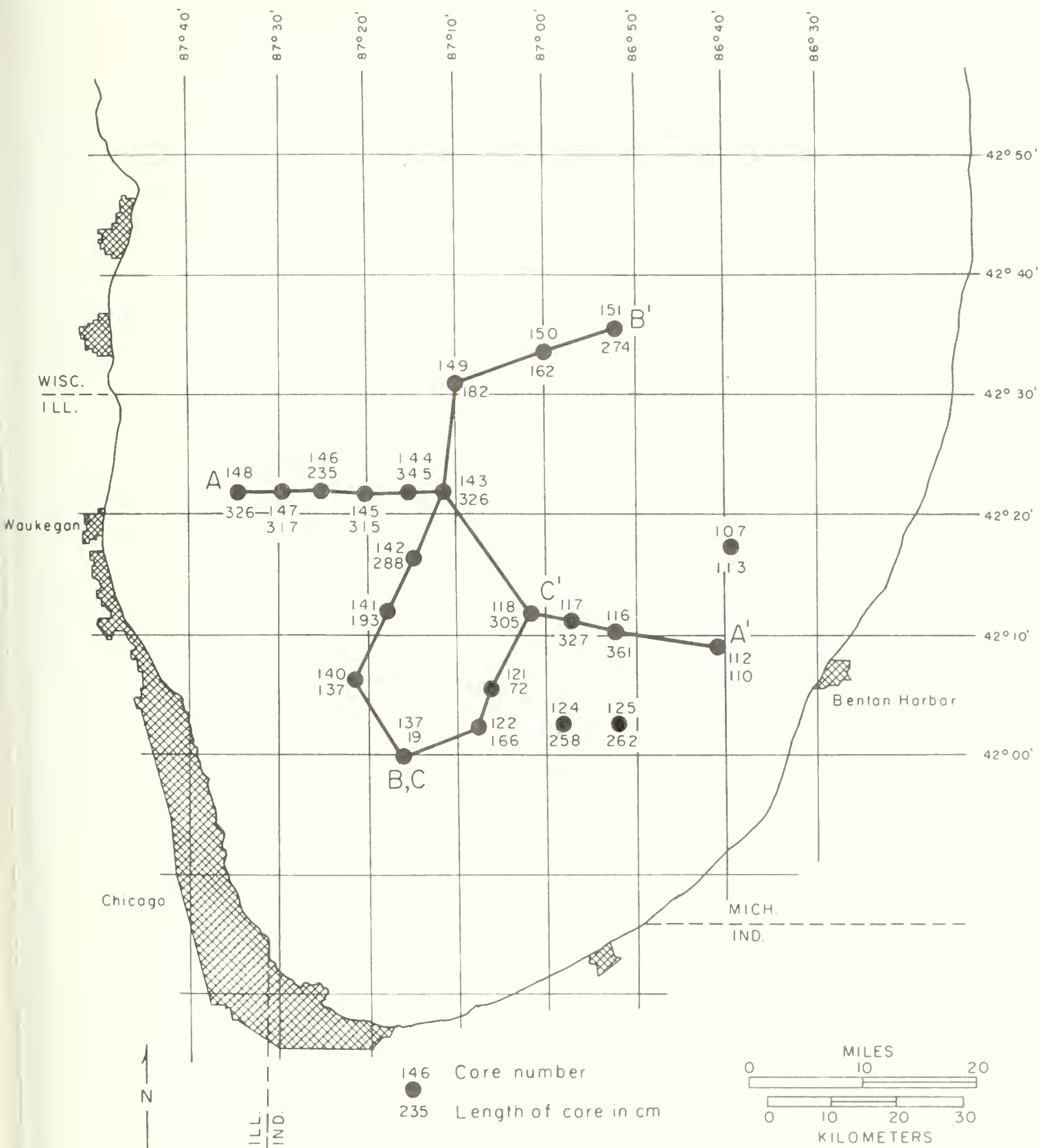


Figure 1—Location of cores and thickness (in cm) of sediment recovered. Also shown are the lines of cross sections in figures 4 and 5.

The Lake Michigan Formation can be subdivided in offshore areas into an upper dark gray to dark brown sandy to silty clay zone that includes many thin black beds, and a reddish brown to reddish gray lower zone that contains very few darker beds. In the area sampled, the lower zone is found only in the deeper waters of the central part of the southern lake basin, but the upper zone extends to the shore areas. The formation can be further divided into eight subunits and many individual descriptive units (see Core Descriptions). Five subunits of member rank and one named bed are herein established in addition to the previously named Ravinia Member (Willman and Frye, 1970) to help describe and correlate the sediments of the Lake Michigan Formation.

Underlying the Lake Michigan Formation are sediments of glacial origin. These sediments are more sandy and silty than the overlying sediments, have much lower water contents, and are much more compact. Some of the deposits are subaqueous glacial lacustrine sediment deposited while the glaciers melted in the southern lake basin. As such, they are assigned to the Carmi Member of the Equality Formation of Wisconsinan age established by Willman and Frye (1970) (fig. 2).

Tills generally underlie the glacial-lacustrine sediments and have been penetrated in 5 of the 22 cores. The tills are rich in silt and clay and are assigned to the Wadsworth Member of the Wedron Formation (Woodfordian Substage) of Willman and Frye (1970) (fig. 2).

The postglacial floor of southern Lake Michigan is a nearly circular basin, but minor topographic irregularities cause the thickness of the postglacial lacustrine sediments to vary. The irregularities are related to uneven preglacial bedrock topography, unequal thicknesses of glacial deposits, the varied distribution of the sources of lacustrine sediments, and erosion during low-water lake stages, all of which complicate the distribution of lake sediments and their lithologies. Twenty-two shallow cores provide insufficient data for completely determining the distribution of lake sediments, but the high degree of correlation of units penetrated in these few widely scattered cores indicates that the units are widely distributed in the lake basin. The cores do provide a starting point for the understanding and mapping of Lake Michigan sediments.

Previous Studies

Hough published a comprehensive summary of the geology and history of the Great Lakes in 1958 and had already discussed the bottom sediments in southern Lake Michigan in 1935. The sediments also have been studied by Ayers and Hough (1964), Davis and McGeary (1965), Ayers (1967), and Sommers and Josephson (1968). Bottom topography has been illustrated by McKee (1968). Gross et al. (1970a) in a preliminary report described cores 143 through 148 and discussed sampling techniques. Shimp, Leland, and White (1970) and Leland, Shimp, and White (1970) discussed the chemical composition of southern Lake Michigan sediments. Gross et al. (1970b) and Collinson et al. (1970) described sediments from southwestern Lake Michigan. Ayer will discuss techniques and results of the radiography of the cores in a forthcoming paper.


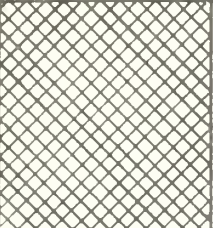
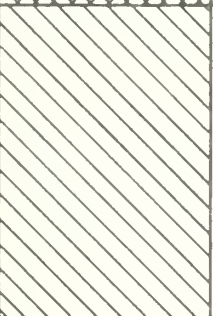


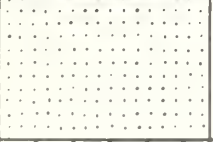
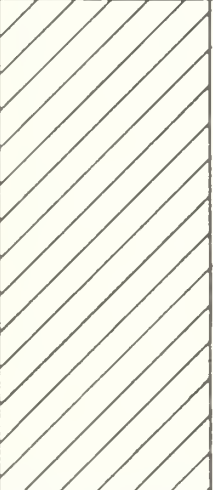
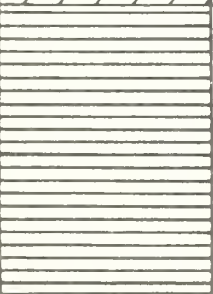

		Fm.	Member	Description
PLEISTOCENE SERIES	HOLOCENE STAGE		Ravinia	Sand on beaches
			Waukegan	Soft, dark gray to brown sandy silt to silty clay, sand, and gravel
			Lake Forest	Dark gray silty clay with black beds and mottling; more compact than Waukegan Member
			Winnetka	Dark brownish gray clay; a few black beds and some black mottling
			Sheboygan	Reddish brown clay
	WISCONSINAN STAGE		Wilmette Bed	Dark gray clay with some black beds
				Reddish brown clay
			South Haven	Reddish gray clay
			Carmi	Sand, sandy pebbly clay, silt, and clay-pebble conglomerate
			Wadsworth	Gray or brownish gray silty clayey till
	LAKE MICHIGAN			
	WEDRON EQUALITY			

Figure 2—Generalized stratigraphic column for unconsolidated late Pleistocene sediments underlying southern Lake Michigan.

The nomenclature used in this report conforms to that proposed by Willman and Frye (1970), who discussed the stratigraphy and nomenclature of the entire Pleistocene of Illinois.

Lake Michigan Formation

The entire Lake Michigan Formation was penetrated in 8 of the 22 cores and ranged from 16 to 270 cm thick, but in some other cores over 360 cm was penetrated without reaching the bottom of the formation (fig. 3). The formation is here divided into six formally named members and one bed (fig. 2). Names are taken from towns and cities along the shore, and the type section for all except the Ravinia Member is designated as core 143, with reference sections 118, 145, and 151 (see Core Descriptions). All units are widely traceable throughout the Lake Michigan Basin (figs. 4 and 5). They are differentiated by color, grain size, mineralogy, water content, and presence or absence of black beds or black mottling. All units are readily distinguishable visually in cores of the Lake Michigan Formation sediments.

Ravinia Member

The modern beach sands of Lake Michigan and other lakes were included in the Ravinia Sand Member of the Lake Michigan Formation by Willman and Frye (1970). The sands on the present beaches of Lake Michigan are well sorted, nearly white, and relatively clean (Willman and Frye, 1970). As most of the beach sands included in the Ravinia occur around the shores of Lake Michigan, they were not penetrated in any cores discussed here. The member ranges in thickness from zero to several meters. The Ravinia Member is a shore facies of the entire Lake Michigan Formation in some places, but in others it may grade laterally into the Waukegan Member. The Ravinia Member is separated from the rest of the formation at the base of the low-water swash zone, and sands occurring offshore are included in the Waukegan Member.

Waukegan Member

The Waukegan Member of the Lake Michigan Formation is the surficial sediment unit of the formation in the offshore areas. It varies from a soft, sandy silt or silty clay with a very high water content to sand and gravel; it contains more sand than the rest of the formation. The Waukegan Member is generally dark gray, but may also be brown or yellowish brown. It averages 18 cm thick, ranging from 2 to 80 cm in the southern lake basin (fig. 6A). The Waukegan has been present in all cores taken thus far, but it may be absent locally over bedrock or till exposures on the lake floor (figs. 4 and 5). The Waukegan Member becomes more sandy nearshore and also in the southwestern part of the lake where sand and gravel covers the lake bottom. These coarser deposits are included in the member. The Waukegan Member was deposited during the late Holocene and is the unit in which lead and other trace elements are concentrated, presumably from pollution (Shimp, Leland, and White, 1970).

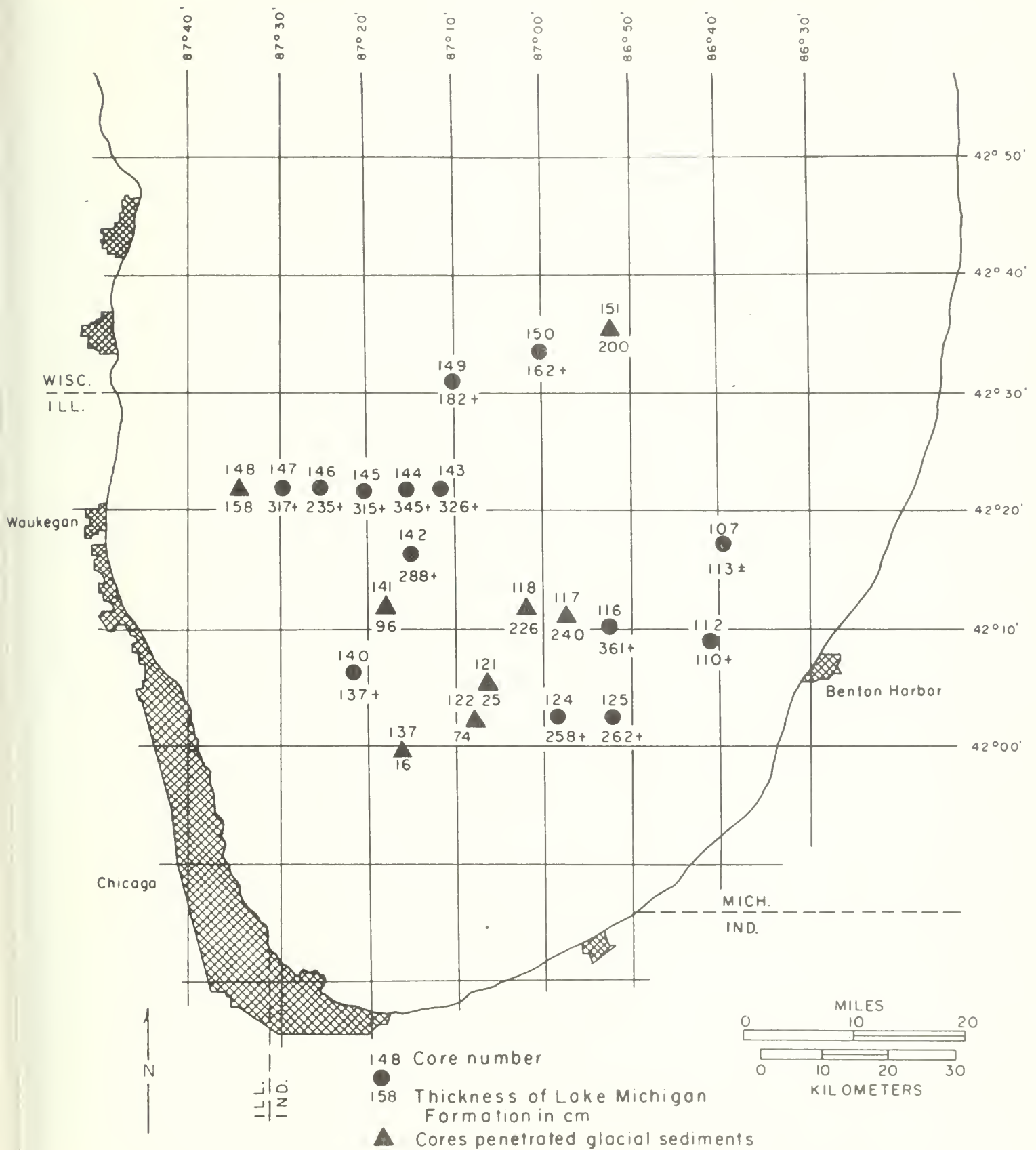


Figure 3—Thickness of Lake Michigan Formation and location of cores penetrating glacially derived sediments of the Equality and Wedron Formations.

The Waukegan Member is named for Waukegan, Lake County, Illinois, and its type section is designated as the interval from 0 to 16 cm in core 143 (see Core Descriptions).

Lake Forest Member (New)

The Lake Forest Member of the Lake Michigan Formation consists of dark gray silty clay that usually contains many thin beds of black clay, which are probably rich in hydrous iron sulfide (hydrotroilite). The black color disappears rapidly when the cores are exposed to air. The black beds contain more organic matter (up to 4 percent) than the surrounding clay and have been dated by the radiocarbon method. A date of 6920 ± 200 years B.P. (ISGS-33) was determined from core 146 by Stephen Kim in the laboratories of the Illinois State Geological Survey (Gross et al., 1970a). This is an average date for the Lake Forest Member (core interval 26 to 106 cm) in that core. Subsequently, a date of 7050 ± 200 years B.P. (ISGS-36) was determined for a combined sample of the Lake Forest Member from cores 143 (16 to 35 cm) and 144 (35 to 65 cm). The sediments below the Lake Forest Member are therefore more than 7000 years old. Black mottling by material of the same composition as the black beds is present in the gray clay between the black beds.

The Lake Forest is generally more silty than underlying units, and is less sandy, more compact, and has a lower water content than the Waukegan Member.

The Lake Forest Member averages 49 cm and ranges between 0 and more than 120 cm thick. It is present on the western and southern sides of the southern lake basin but is absent from the central and eastern parts (fig. 6B). The member apparently pinches out or grades into the underlying Winnetka Member to the east (fig. 4).

The Lake Forest Member is named for Lake Forest, Lake County, Illinois, and its type section is designated as the interval from 16 to 35.5 cm of core 143 (see Core Descriptions).

Winnetka Member (New)

The Winnetka Member of the Lake Michigan Formation contains brownish gray clay with a few interspersed black beds. It becomes somewhat sandy near shore, but it is generally finer grained than the overlying members. The Winnetka Member is darker and contains more black beds than the underlying Sheboygan Member. The Winnetka Member averages 83 cm thick and ranges between 31 and 182 cm. It is thickest where it apparently occupies a channel eroded into the underlying Sheboygan Member (core 144, fig. 4) and is absent in areas where glacial sediments are near the sediment surface. The Winnetka Member is slightly thicker on the east side of the lake than on the west (fig. 6C).

The Winnetka Member is named for Winnetka, Cook County, Illinois. Its type section is designated as the interval between 35.5 and 112.0 cm in core 143 (see Core Descriptions).

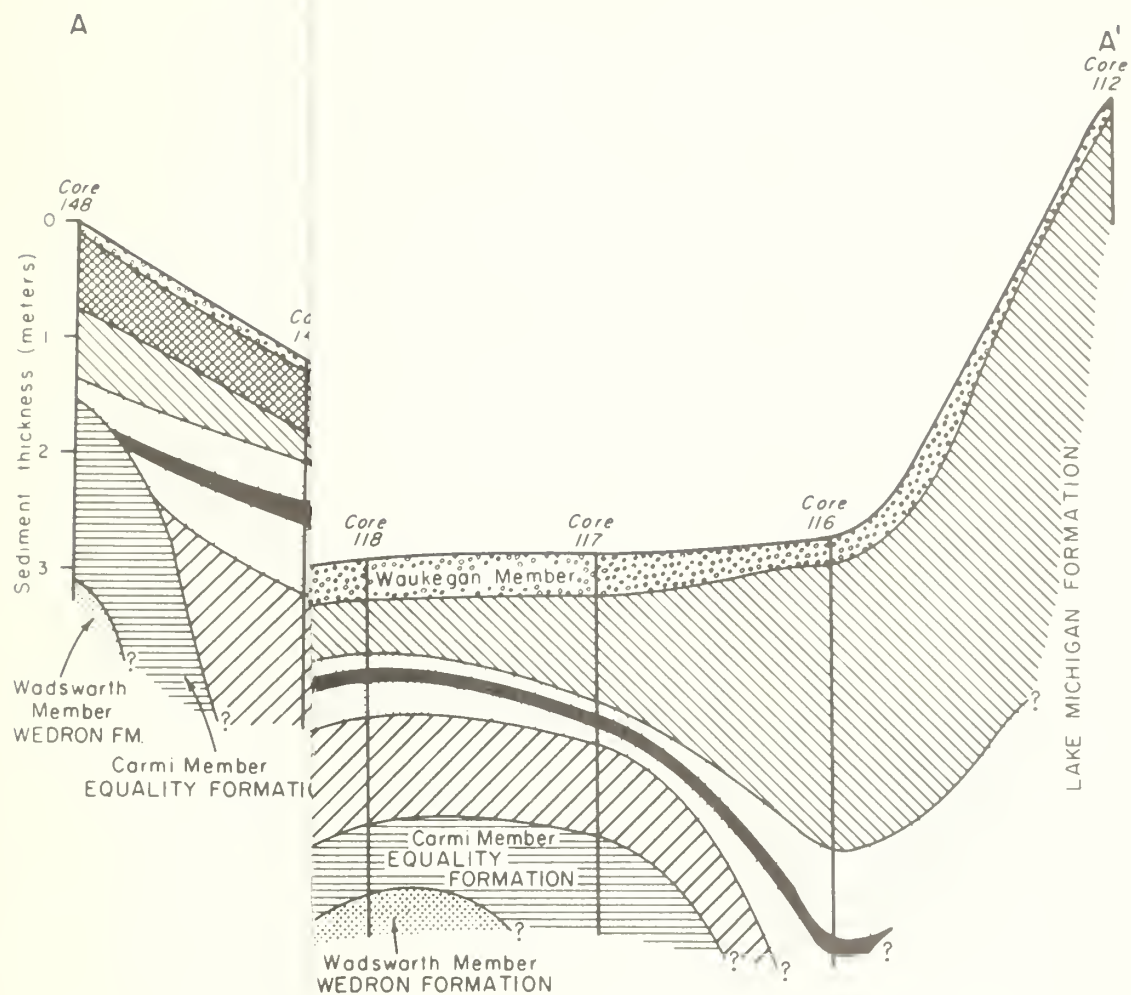


Figure 1.

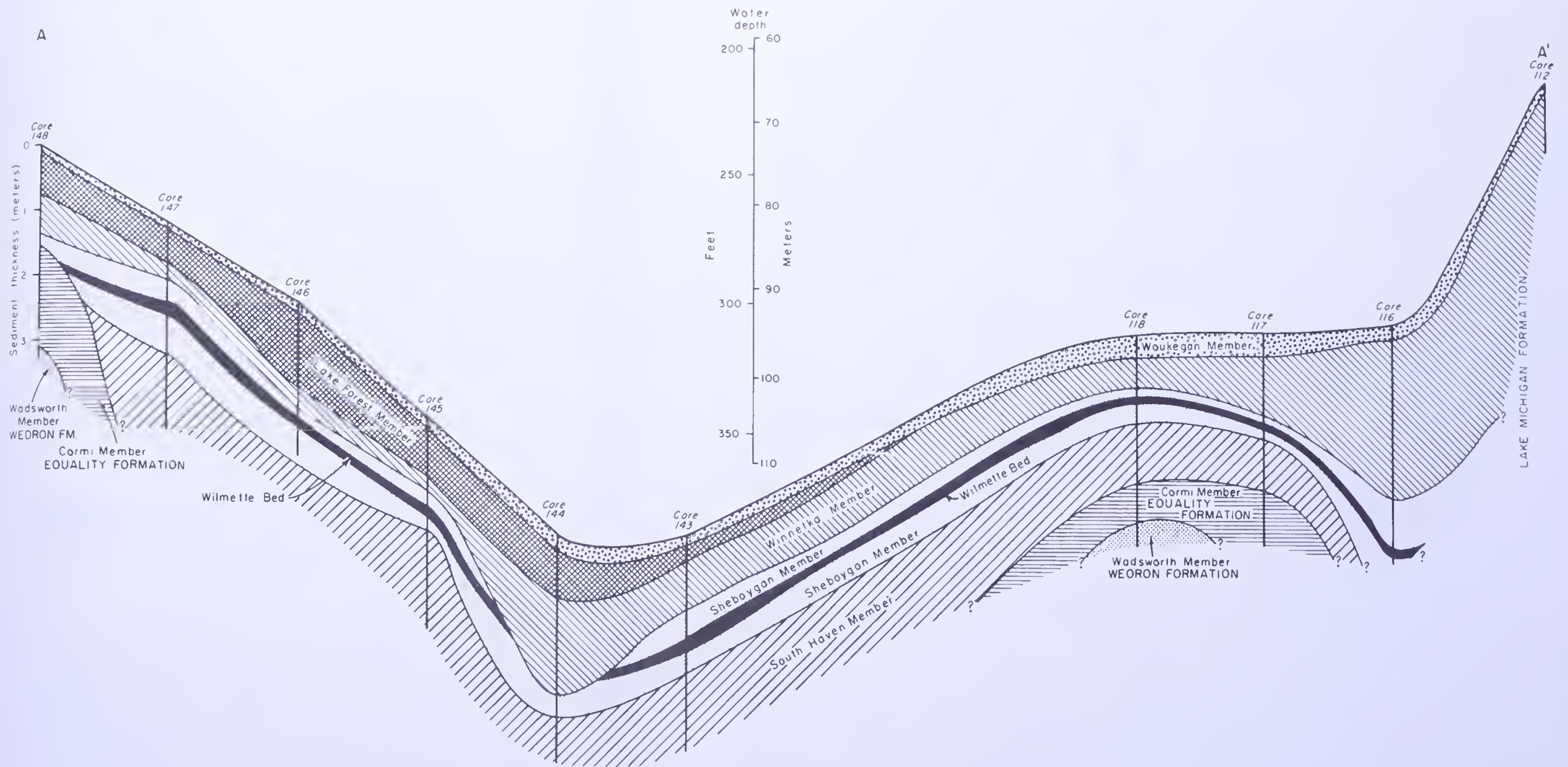
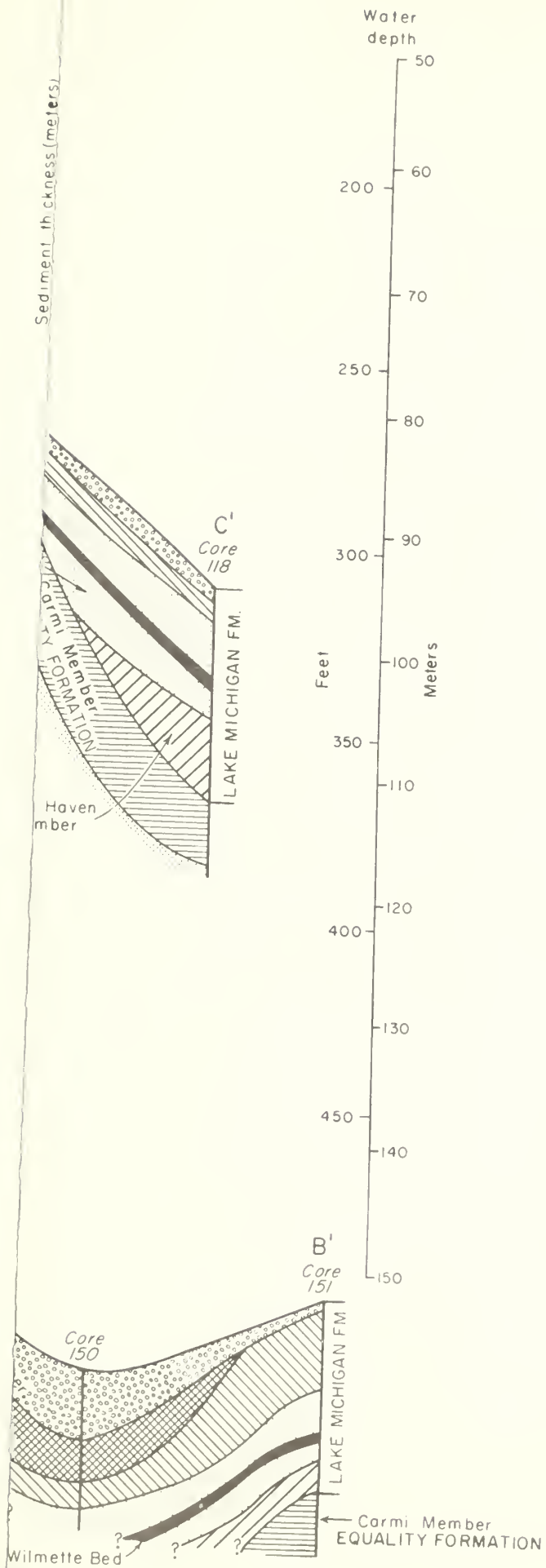


Figure 4—East-west cross section across southern Lake Michigan. Location shown in figure 1.



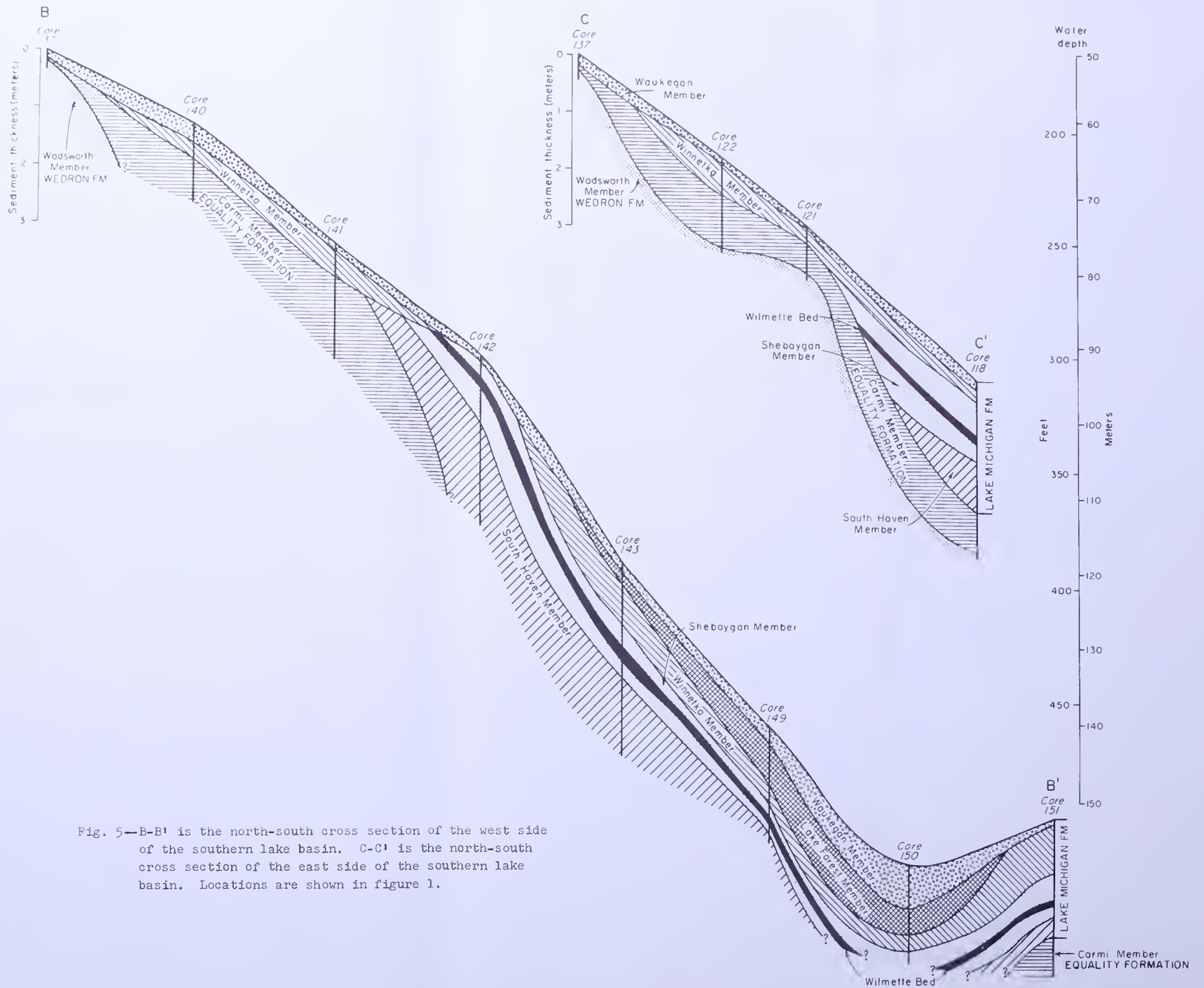


Fig. 5—B-B' is the north-south cross section of the west side of the southern lake basin. C-C' is the north-south cross section of the east side of the southern lake basin. Locations are shown in figure 1.

Sheboygan Member (New)

The Sheboygan Member of the Lake Michigan Formation consists of two reddish brown to brown clay units separated by a thin, persistent, gray clay bed. The Sheboygan Member averages 73 cm thick and ranges from 0 (in areas where the Winnetka Member overlies glacial sediments) up to 120 cm (fig. 6D). It is present only where the water in the southern lake basin is more than 233 feet (71.0 m) deep. It is absent from the southwestern part of the lake and thins shoreward to the east and west (figs. 4 and 5). Hough (1958) reported a similar distribution for this unit, but reported that it occurs only in water more than 350 feet (106.7 m) deep. The member, however, has been penetrated in cores taken in water only 233 feet (71.0 m) deep (core 124).

The Sheboygan Member is named for Sheboygan, Sheboygan County, Wisconsin, and its type section is designated as the interval from 112.0 to 219.3 cm of core 143 (see Core Descriptions). The upper part of the Sheboygan Member, above the gray clay bed, contains a few thin, brown or grayish brown clay layers and is absent in an area in the central and southwestern part of the southern lake basin. In other places it ranges between 12 and 44 cm thick.

The gray clay bed in the middle of the Sheboygan Member is a widespread marker bed in the southern Lake Michigan Basin (Gross et al., 1970a; Hough, 1935, 1958) (figs. 4 and 5). However, it has been found only in areas where water is more than 270 feet (82.3 m) deep. Because it is useful as a marker bed, the gray clay bed is here formally designated the Wilmette Bed of the Sheboygan Member of the Lake Michigan Formation. Its type section is the interval between 152 and 174 cm of core 143 (see Core Descriptions). The Wilmette Bed averages 13 cm and ranges from 5 to 22 cm thick (fig. 6E). It consists of dark gray clay with some black beds and is very similar in appearance to the Lake Forest Member. Unlike the rest of the Sheboygan Member, the Wilmette Bed also contains traces of sand, as does the Lake Forest Member. The boundaries of the Wilmette Bed may be gradational in some places, but they are quite sharp in others. The bed apparently represents some significant, unknown event in the history of the deeper Lake Michigan Basin. The bed is named for the city of Wilmette, Cook County, Illinois.

The lower part of the Sheboygan Member is much like the part above the Wilmette Bed and has a similar distribution. It ranges from 14 to 57 cm thick and is absent in cores from shallow water.

South Haven Member (New)

The South Haven Member of the Lake Michigan Formation is a reddish gray clay. It is the lowest unit of the Lake Michigan Formation, overlies glacially derived deposits of the Equality or Wedron Formations, and is the lowermost unit penetrated in many cores (figs. 4 and 5). The known thickness of the South Haven Member ranges between 30 and 94 cm, but several cores on the west side of the southern lake basin penetrated as much as 177 cm (core 142) of reddish gray clay without reaching the bottom of the member (fig. 6F). It is generally less than 100 cm thick on the east side of the lake. The South Haven Member consists mainly of homogeneous clay, but laminations of lighter and darker clay are present, particularly in the lower part.

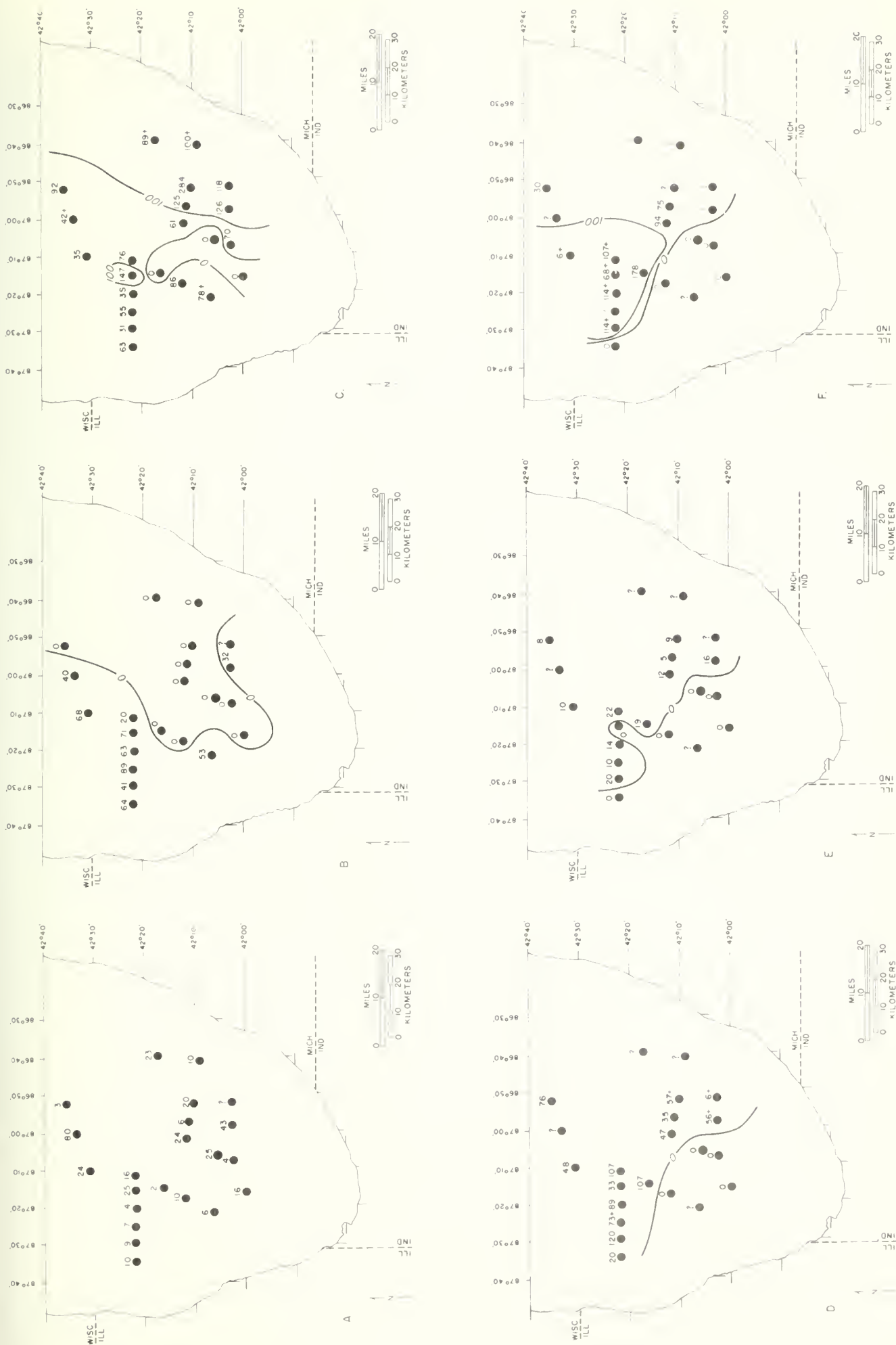


Fig. 6—Maps showing thickness (in cm) and distribution of units of the Lake Michigan Formation in southern Lake Michigan. A. Waukegan Member; B. Lake Forest Member; C. Winnetka Member; D. Sheboygan Member (total); E. Wilmette Bed; F. South Haven Member.

The South Haven Member is named for South Haven, Ottawa County, Michigan, and its type section is the interval in core 143 from 219.3 cm to the base. Because the entire thickness of the member was not penetrated in core 143, the interval 170.5 to 200 cm in core 151 is designated as a reference section (see Core Descriptions).

Equality Formation

Carmi Member

The Equality Formation (Willman and Frye, 1970) includes deposits formed in glacial lakes. The Carmi Member of the Equality Formation (Willman and Frye, 1970) consists of relatively deep-water sediments. As the ice melted in the southern lake basin, a glacial lake formed in front of the retreating ice sheet because natural outlets to the north were blocked. This lake stage has been called the Lake Chicago Stage by Bretz (1951, p. 404). Glacial-lacustrine deposits below the Lake Michigan Formation and above till and outwash were penetrated in 7 of the 22 cores in the southern Lake Michigan Basin (fig. 3). These deposits are here assigned to the Carmi Member of the Equality Formation.

The Carmi Member consists of gray to brownish gray sandy silt, varved lacustrine clay, pebbly sandy clay and silt, sand, and clay-pebble conglomerate. Sediments of the Carmi Member are much more cohesive and compact than those of the Lake Michigan Formation, have lower water contents, and contain more sand and pebbles. The Carmi Member is present in core 151, 200 to 274 cm (see Core Descriptions).

Three widely spaced cores (151, 117, and 148) penetrated a thin bed of clay-pebble conglomerate. The conglomerate is similar in appearance in all three cores, including one from 500 feet of water, which indicates some widespread episode in lake history. The conglomerate consists of subrounded pebbles of red, gray, and brown clay up to 1 cm in diameter that are similar to the clay of the units above and below. The pebbles are enclosed in a sandy clay matrix.

Wedron Formation

The Wedron Formation (Frye et al., 1968) includes all tills and associated deposits of Woodfordian age in Illinois, including those under southern Lake Michigan. North of Illinois the Wedron is overlain by deposits of the Twocreekan and Valderan Substages, but in the southern lake basin the Wedron is overlain by the Equality Formation or Lake Michigan Formation.

Wadsworth Member

The Wadsworth Member of the Wedron Formation (Willman and Frye, 1970) consists of the youngest tills of Woodfordian age found in the Lake Border

Morainic System and part of the Valparaiso Morainic System. Tills associated with these moraines are rich in clay and extend out under Lake Michigan (Willman and Frye, 1970). A few centimeters of compact, silty, clay-rich till were penetrated in five cores (118, 121, 122, 137, and 148) taken in southern Lake Michigan. Grain-size analyses of three till samples show 17, 7, and 9 percent sand, 48, 46, and 53 percent silt, and 35, 47, and 38 percent clay, respectively. Four till samples are gray, and one on the west side of the lake is brownish gray. The tills are also rich in illite, like their on-shore counterparts.

CONCLUSION

The stratigraphy of sediments from southern Lake Michigan outlined in this report provides a framework for future discussion and correlation of individual units and for a study of their distribution and sedimentology in the entire southern lake basin. Future cores will undoubtedly expand and modify the present classification. Many problems remain unsolved: the nature and distribution of Lake Michigan Formation sediments in shallow water areas is largely unknown because of difficulties in coring; the age of the oldest Lake Michigan Formation sediments awaits dating; and the sources and mechanisms of deposition of these sediments are subject to future interpretation. The Illinois State Geological Survey is conducting further studies of Lake Michigan sediments in an attempt to solve these problems.

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APPENDIX

CORE DESCRIPTIONS

All cores described here are (47 mm) gravity cores from southern Lake Michigan taken from the R. V. INLAND SEAS, September 1969. Cores 143, 118, 145, and 151 are described in detail, the remainder by stratigraphic unit. Colors are described by the standard Munsell notation.

Core 143

Lat. 42°21.8' N, long. 87°10.8' W; water depth 390 feet (118.9 m).

Type section of Lake Michigan Formation and its members.

Pleistocene Series

Lake Michigan Formation	Depth (cm)
-------------------------	---------------

Waukegan Member

- | | |
|--|------|
| 1. Yellowish brown silt, mixed rusty and olive; sample disturbed; sharp base; soft, water saturated; 10 YR 5/4 | 4.7 |
| 2. Dark brown clayey silt, somewhat disturbed; base gradational; 10 YR 3/3 | 8.2 |
| 3. Dark grayish brown clayey silt; becomes lighter toward base; 10 YR 4/2 | 12.1 |
| 4. Rusty yellow layer with sharp contacts | 12.2 |
| 5. Grayish brown silty clay, massive; a few small fossils; 10 YR 5/2 | 15.9 |

Lake Forest Member

- | | |
|---|------|
| 6. Black clay with sharp contacts | 16.3 |
| 7. Gray silty clay; no visible bedding; a few small fossils; 10 YR 5/1 | 18.7 |
| 8. Same as above with dark gray to black mottling | 19.5 |
| 9. Gray silty clay; no visible bedding; a few small fossils; 10 YR 5/1 | 23.0 |
| 10. Same as above with black mottling | 23.7 |
| 11. Gray silty clay; no visible bedding; a few small fossils; black mottling near base; 10 YR 5/1 | 30.1 |
| 12. Same as above with 60% black mottling | 30.8 |

	Depth (cm)
Lake Forest Member (Continued)	
13. Gray silty clay with black mottling near base, fossiliferous; 10 YR 5/1	34.9
14. Black clay bed; greasy feel; sharp contacts	35.6
Winnetka Member	
15. Grayish brown clay with trace of sand; sharp 1-mm gray band at 38.1 cm; 10 YR 5/2	40.5
16. Same as above with 40% black mottling; indistinct 5-mm black beds at 42.5, 44.5, and 45.7 cm; abundant small fossils	46.0
17. Grayish brown silty clay with abundant sand; 10 YR 5/2 . .	48.5
18. Dark brown silty clay with a few very small fossils and black mottling in lower two-thirds; 10 YR 4/3	51.8
19. Same as above, grading from slight black mottling near top to 80% mottling at base	55.7
20. Black clay bed; 7.5 YR 5/2	56.4
21. Brown clay; hint of lamination; gradational base	61.0
22. Same as above but grayer; 10 YR 5/2	67.9
23. Same as above, with scattered black mottling; mottling decreases downward; faint 5-mm thick black beds at 68.2 and 70.0 cm	76.3
24. Brown clay with faint black mottling scattered throughout; cohesive; 7.5 YR 5/2	95.0
25. Same as above but more black mottling	112.0
Sheboygan Member	
26. Dark reddish gray clay; core broken and deformed on extrusion; gradational base; 5 YR 4/2	129.6
27. Dark gray clay; gradational contacts; 10 YR 4/1	133.2
28. Brown clay; 7.5 YR 5/2	152.0
Wilmette Bed	
29. Dark gray clay; top contact sharp; base gradational; black mottling in upper 1 cm; 5 YR 4/1	164.5

Wilmette Bed (Continued)	Depth (cm)
30. Gray to brownish gray clay; unit gradational with units above and below; contains compressional deformation; 10 YR 5/1	174.0
31. Brown clay, homogeneous; 7.5 YR 5/2	183.7
32. Dark reddish gray clay; 5 YR 5.5/2	185.5
33. Dark brown clay; 7.5 YR 4/2	186.7
34. Dark reddish gray clay; 5 YR 5.5/2	192.5
35. Reddish brown clay; 2.5 YR 4/4	196.0
36. Reddish brown clay with faint gray-tan banding; 5 YR 4/4. .	207.0
37. Medium reddish brown clay; 5 YR 5/3	219.3
South Haven Member	
38. Medium reddish brown clay grading to reddish gray at base; homogeneous; base gradational; 5 YR 5/3	280.0
39. Same as above but slightly grayer; 5 YR 5/2; 7.5 YR 5/2 . .	291.0
40. Reddish gray clay with very faint gray bands; 5 YR 5/2 . .	326.0

Core 118

Lat. 42°12.0' N, long. 87°01.8' W; water depth 312 feet (95.1 m).

Pleistocene Series

Lake Michigan Formation	Depth (cm)
Waukegan Member	
1. Brown silty clay with considerable amounts of sand; fossils quite common; faint mottling of gray; moderately soft, water saturated; 7.5 YR 5/4	16.0
2. Brown silty clay; contains trace of sand; firmer and slightly lighter in color than unit 1; contains fossils and specks of dark gray to black organic material; 7.5 YR 5/4.	20.0
3. Several 1-mm beds of yellowish brown sediment separated by sediment like unit 2	21.0

	Depth (cm)
Waukegan Member (Continued)	
4. Reddish brown clay; fossils common; 5 YR 5/4	24.0
5. Layer of yellowish brown sediment firmer than surrounding clay; 7.5 YR 5/6	24.1
Winnetka Member	
6. Brown clay with scattered specks of dark material and scattered small fossils; shows faint lamination of brown and grayish brown clay; 7.5 YR 5/4	33.0
7. Reddish brown clay, generally massive in appearance, but contains some faint grayish brown laminations; scattered dark gray mottling in lower 4 cm; indistinct base; 5 YR 5/3	85.0
Sheboygan Member	
8. Reddish brown clay, slightly more orange than clay above; indistinct contacts above and below; 5 YR 5/3.5	89.6
9. Reddish gray clay; indistinct contact; 5 YR 5/2	92.6
10. Reddish brown clay; indistinct contact; 5 YR 5/2.5	97.2
Wilmette Bed	
11. Dark gray clay; 5 Y 4/1	102.2
12. Clay as above, with irregular black mottling	104.0
13. Clay as above	105.7
14. Clay as above, with scattered black mottling	107.1
15. Dark gray clay; indistinct contacts gradational into unit below; 10 YR 4/1	109.5
16. Reddish brown clay; gradational upper and lower contacts; contains scattered black mottling in upper 2 cm; becomes more red towards base; 5 YR 5/2.5	122.5
17. Reddish brown clay, more orange than clay above; 5 YR 4/4	126.5
18. Reddish gray clay	128.0
19. Reddish brown clay, more orange than units above and below; 5 YR 4/4	132.0

	Depth (cm)
South Haven Member	
20. Reddish brown clay, massive; slightly grayer zone near base. Sediment loss at cut 165.5 to 168.0 cm; 5 YR 5/3 . .	212.3
21. Reddish brown clay; more orange than unit above; 5 YR 4/3 .	213.2
22. Reddish gray clay; 5 YR 5/2	214.3
23. Reddish brown clay (as in unit 21)	214.8
24. Reddish gray clay, very faint banding; 5 YR 5/2	223.8
25. Brown clay; contains faint 2-3 mm laminations of alternating grayer and redder clay; trace of sand; 7.5 YR 5/2	226.5

Equality Formation

Carmi Member

26. Silty fine sand, gray; firmer and drier than sediment above; 10 YR 5/1	231.5
27. Sandy silt, grayish brown; contains indistinct beds 1-5 mm thick, alternating dark and light brownish gray with a few gray beds; some coarse sand and pebbles; 1 pebble 1 cm in diameter	238.5
28. Gray sandy silt with some coarse sand; some faint bedding; some grit-size (2-4 mm) fragments; 1 pebble at base 1.5 cm in diameter; 5 Y 5/1	262.5
29. Gray silty clay with some sand; faint laminations; irregular darker gray zone at 280-285 cm; 10 YR 5/1	293.0

Wedron Formation

Wadsworth Member

30. Gray silty clay till with some sand and pebbles 6 mm in diameter; 10 YR 5/1	305.5
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Core 145

Lat. 42°21.8' N, long. 87°20.3' W; water depth 346 feet (105.5 m)

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
1. Clay with trace of fine sand, soft; 10 YR 3/3	3.0

Waukegan Member (Continued)	Depth (cm)
2. Gray clay layers 1-mm thick, compact, with trace of fine sand or silt alternating with layers of yellow-brown clay; 10 YR 4/3, 10 YR 4/4	5.0
3. Gray clay with trace of silt; some mottling of lighter gray; 10 YR 3/2	8.0
4. Three yellow-brown silt beds 1-mm thick; separated by gray clay like unit 2	10.0
5. Dark gray clay, soft; 10 YR 3/1	14.0
Lake Forest Member	
6. Black clay	14.1
7. Dark gray silty clay; 10 YR 3/1	18.0
8. Black clay mottled with gray clay	20.0
9. Gray silty clay; 10 YR 4/2	20.7
10. Black clay	20.8
11. Gray clay, silty; 10 YR 4/1	21.9
12. Black clay	22.0
13. Gray clay, silty; 10 YR 4/1	23.7
14. Gray silty clay mottled with black and gray silt and with thin indistinct beds of black clay; 10 YR 4/1	25.6
15. Black clay	25.8
16. Same as 14 but black mottling toward bottom	30.5
17. Gray clay with a little black mottling	31.5
18. Black clay	31.6
19. Gray clay, silty	31.9
20. Gray clay with a little dark gray mottling	33.8
21. Black clay	33.9
22. Gray clay, lighter in color than clay units above, silty; 10 YR 4/2	38.6
23. Black clay	38.8

Lake Forest Member (Continued)	Depth (cm)
24. Gray silty clay with black mottling	40.1
25. Mostly black clay with some gray mottling; 10 YR 4/2 . . .	41.3
26. Gray clay, silty; 10 YR 4/2	46.3
27. Black clay	46.5
28. Gray clay, silty; 10 YR 4/2	48.0
29. Mostly black clay with some gray mottling	49.0
30. Mostly gray silty clay with some black mottling; 10 YR 4/2.	50.0
31. Black clay	50.2
32. Alternating indistinct beds of black and gray clay	52.8
33. Gray clay with a little black mottling	55.1
34. Indistinct alternating layers of black and gray clay . . .	56.5
35. Gray silty clay with some black mottling	58.2
36. Black clay	58.4
37. Gray clay, silty; 10 YR 5/1	61.8
38. Black clay with some gray mottling	62.0
39. Gray clay with a very little black mottling; 10 YR 5/1 . .	66.0
40. Black clay with some gray mottling	67.0
41. Gray silty clay with a little fine sand; 10 YR 4/2	73.8
42. Gray clay mottled with indistinct black beds	76.9
Winnetka Member	
43. Clay, brownish gray; 10 YR 4/2	79.0
44. Black clay	79.2
45. Gray clay	80.6
46. Black clay, somewhat lenticular	80.7
47. Gray clay	83.6

Winnetka Member (Continued)	Depth (cm)
48. Gray clay with black mottling	87.6
49. Black clay	87.8
50. Gray clay; 10 YR 4/1	89.3
51. Black clay	89.4
52. Gray clay with some black mottling; 10 YR 4/1	91.8
53. Brownish gray clay with a few black streaks; 10 YR 5/3 . .	97.1
54. Black clay	97.2
55. Brownish gray clay with some black specks in middle. The contact of this unit and unit below is a sharp color break. A few fossil clams near base; 10 YR 5/3	111.8
Sheboygan Member	
56. Reddish brown clay; 5 YR 4/2	114.3
57. Reddish brown clay with a few black specks	117.5
58. Brownish gray clay; 5 YR 5/2	130.6
59. Brownish gray clay with black mottling	133.5
60. Brownish gray clay; significant contact at base	138.3
Wilmette Bed	
61. Black clay	138.4
62. Dark gray silty clay mottled with indistinct bands of black; some beds 1 mm thick near top; 10 YR 3.5/1 . .	152.3
63. Brownish gray clay with a little black mottling; 5 YR 4.5/2	162.5
64. Reddish brown clay; 5 YR 4.5/3	172.3
65. Gray clay; indistinct upper and lower contact; 5 YR 5/2 . .	174.3
66. Orangish gray clay; 5 YR 4/4	187.5
67. Clay, slightly grayer than above; 5 YR 4/2	188.7
68. Orangish gray clay; 5 YR 4/3	201.0

	Depth (cm)
South Haven Member	
69. Reddish gray clay; becomes slightly grayer toward the base; distinct, very thin black bed at 229 cm; 5 YR 4/4	315.0

Core 151

Lat. 42°36.5' N, long. 86°47.4' W; water depth 500 feet (152.4 m)

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	

Waukegan Member

1. Yellowish brown sandy surficial sediment (Note: 0 to 83 cm frozen; detailed description not possible)	3.0
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Winnetka Member

2. Brown to reddish brown silty clay	20.0
3. Very dark gray clay, fossiliferous	29.0
4. Medium brown clay	37.0
5. Brownish gray clay with trace of black mottling; 7.5 YR 5/2.5	95.0

Sheboygan Member

6. Brown clay; gray silty beds at 12.0, 19.0, and 26.5 cm; 7.5 YR 5/3	138.7
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Wilmette Bed

7. Gray clay with intense black mottling in uppermost 1 cm and in lowermost 3 cm; trace of black mottling in remainder; moderately sharp top; base gradational; 5 Y 5/1	146.4
8. Light to dark reddish brown clay with faint laminations; 5 YR 4/4	170.5

South Haven Member

9. Reddish gray clay alternating with grayish brown clay; prominent laminations; 5 YR 5/3	200.0
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Equality Formation	Depth (cm)
Carmi Member	
10. Brown silt with some clay pebbles (reddish brown 5 YR 5/4, pinkish gray 7.5 YR 6/2, and gray 5 YR 5/1); 10 YR 5/3 (matrix)	205.0
11. Brown clay-pebble conglomerate, sandy; clay pebbles very closely packed; 7.5 YR 5/2	223.0
12. Grayish brown sandy silt with scattered clay pebbles; faintly laminated; pebbles gray, reddish brown, and grayish brown; 10 YR 5/2	253.0
13. Gray, sandy, clayey silt with scattered clay pebbles and rock fragments; thinly laminated; rock fragments up to 1 cm in diameter; 10 YR 5/1	274.0

Core 107

Lat. 42°16.7' N, long. 87°39.7' W; water depth 195 feet (59.4 m). Core frozen.

Pleistocene Series

Lake Michigan Formation	Depth (cm)
Waukegan Member	
Brownish gray to dark gray silty clay	23.0
Winnetka Member	
Dark brownish gray silty clay	112.5

Core 112

Lat. 42°08.7' N, long. 86°41.4' W; water depth 210 feet (64.0 m). Core frozen.

Pleistocene Series

Lake Michigan Formation	Depth (cm)
Waukegan Member	
Dark gray sandy silty clay	10.0
Winnetka Member	
Dark grayish brown clay	110.5

Core 116

Lat. 42°11.5' N, long. 86°52.8' W; water depth 308 feet (93.9 m).
Core frozen from 0 to 112.5 cm.

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Dark gray silty clay	20.0
Winnetka Member	
Brownish gray to dark grayish brown and brown clay with a trace of fine sand; faint black beds and mottling; silt beds near base; twig at about 203.5 cm; 10 YR 5/2 and 4/2, 7.5 YR 4/2	303.5
Sheboygan Member	
Brown to reddish brown clay; some black mottling; 7.5 YR 5/2 .	343.8
Wilmette Bed	
Gray clay, with some black mottling in upper part; 5 Y 5/1	353.0
Dark brown to reddish brown clay; 7.5 YR 4/2	360.5

Core 117

Lat. 42°11.3' N, long. 86°57.3' W; water depth 312 feet (95.1 m).

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Brown sandy clay, very soft; 10 YR 5/4	6.0
Winnetka Member	
Brown to grayish brown clay, soft; faint varves; 7.5 YR 4/4 to 10 YR 4/3	130.5
Sheboygan Member	
Reddish brown to reddish gray clay; faint varving; 5 YR 5/3 to 5/2	146.0

Sheboygan Member (Continued)

Depth
(cm)

Wilmette Bed

Gray clay; bedding not visible; 5 Y 5/1 151.0

Reddish brown clay; 5 YR 5/2.5 165.0

South Haven Member

Reddish brown to reddish gray clay; 5 YR 4/3 to 5 YR 5/2 . . . 240.0

Equality Formation

Carmi Member

Reddish gray clay-pebble conglomerate; sandy matrix; pebbles
up to 1 cm in diameter; some gray silt; 5 YR 5/2 276.0

Dark gray silty clay; a few clay pebbles; laminated with
brownish gray clay layers; 10 YR 4/1 326.5

Core 121

Lat. 42°05.3' N, long. 87°05.7' W; water depth 243 feet (74.1 m).

Pleistocene Series

Lake Michigan Formation

Depth
(cm)

Waukegan Member

Brown sandy clayey silt; darker toward base; a few fossils;
10 YR 5/4 25.5

Equality Formation

Carmi Member

Gravel, rounded, up to 3 cm in diameter; gray to brownish gray
sandy silt containing clay pebbles and rock fragments; 10 YR
5/1 to 5/2 63.0

Wedron Formation

Wadsworth Member

Gray silty clay till with sand and a few large pebbles;
5 YR 4/1 72.0

Core 122

Lat. 42°02.0' N, long. 87°06.5' W; water depth 213 feet (64.9 m).

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Dark yellow-brown sandy silt with hard cohesive layers	3.8
Winnetka Member	
Brownish gray silty clay with black mottling and a few black beds	74.0
Equality Formation	
Carmi Member	
Dark brown sandy silt with several layers of coarse sand; 10 YR 4/3	117.0
Gray compact silty clay with sand and pebbles up to 2 cm in diameter; thinly laminated, with laminae at an angle with respect to sides of core	160.3
Wedron Formation	
Wadsworth Member	
Dark gray silty clay till with sand and large rock fragments; 10 YR 3/1	166.0

Core 124

Lat. 42°02.0' N; long. 86°57.0' W; water depth 233 feet (71.0 m).

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Very dark gray sandy silt, very soft; some black mottling and two black beds; 5 Y 3/1	43.0
Lake Forest Member	
Very dark gray silty clay with many thin black beds and black mottling; 10 YR 3/1	75.8

	Depth (cm)
Winnetka Member	
Brownish gray clay with prominent black beds in upper part (above 107 cm) and indistinct black beds and mottling in lower part; fossiliferous 10 YR 4/2 to 5/2	201.5
Sheboygan Member	
Brown clay with fossils; 7.5 YR 5/2	224.0
Sand, coarse	226.0
Wilmette Bed	
Dark grayish brown clayey silt	242.6
Reddish brown clay, mottled with gray; 5 YR 4/4	258.0

Core 125

Lat. 42°02.0' N, long. 86°52.3' W; water depth 230 feet (70.1 m). Core frozen.

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan and Lake Forest Members Undifferentiated	
Dark gray silty clay, black beds in lower 30 cm	138.0
Winnetka Member	
Brownish gray clay with black beds, decreasing in frequency downward	256.0
Sheboygan Member	
Dark gray silt, thinly bedded, compact, sharp contact	262.0

Core 137

Lat. 42°00.0' N, long. 87°16.2' W; water depth 168 feet (51.2 m).

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Yellowish brown sand with pebbles and fossils; 10 YR 5/4 . . .	16.0

	Depth (cm)
Wedron Formation	
Wadsworth Member	
Gravel, coarse, up to 3 cm in diameter	17.5
Gray silty clay till with sand; compact; 2.5 Y 4/2	19.0

Core 140

Lat. 42 06.8' N, long. 87 21.4' W; water depth 200 feet (61.0 m).

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Dark grayish brown fine-grained sand; 2.5 YR 4/4	6.0
Lake Forest Member	
Dark gray silty clay with a trace of fine sand; very faint darker gray layers; 5 Y 4/1 to 10 YR 4/1	59.2
Winnetka Member	
Dark grayish brown clay; trace of silt and fine sand; faint laminations of darker gray clay; a few fossils; a few granules; a few plant fragments	137.0

Core 141

Lat. 42°11.6' N, long. 87°18.0' W; water depth 252 feet (76.8 m).

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Yellowish brown sand, soft; 10 YR 5/6	3.5
Dark grayish brown clayey silt, soft, fluid; 10 YR 4/2	10.0
Winnetka Member	
Grayish brown clay with black beds and black mottling; a few fossils; plant fragments; 10 YR 4/2 to 5/2, 7.5 YR 5/2	96.5

Equality Formation	Depth (cm)
Carmi Member	
Brown sandy silt; fossiliferous; 7.5 YR 4/2	104.6
Variegated pebbly silt, brown (7.5 YR 5/2) to grayish brown (2.5 YR 5/2); bedding very obvious and inclined 45° to core; deformed bedding, pebbles of igneous rocks and clay pebbles very hard and compact	193.0

Core 142

Lat. 42°16.2' N, long. 87°14.8' W; water depth 300 feet (91.4 m).

Pleistocene Series

Lake Michigan Formation	Depth (cm)
Waukegan Member	
Dark brown sandy silt; sandier in lower part; 10 YR 4/3	2.2
Sheboygan Member	
Reddish brown to reddish gray clay; faint darker layers; 5 YR 5/3 and 5 YR 4/2	37.6
Wilmette Bed	
Dark gray clay with black mottling; 5 Y 4/1	59.0
Reddish brown to reddish gray clay in alternating beds; 5 YR 4/2 and 5 YR 4/4	109.5
South Haven Member	
Reddish gray clay, homogeneous in upper part; a few darker beds near base; 5 YR 5/2	287.5

Core 144

Lat. 42°21.8' N, long. 87°15.6 W; water depth 390 feet (118.9 m).

Pleistocene Series

Lake Michigan Formation	Depth (cm)
Waukegan Member	
Dark gray silty clay; indistinct black beds and mottling; 5 Y 3/1	25.4

	Depth (cm)
Lake Forest Member	
Very dark gray silty clay; many black beds and black mottling; clay becomes lighter gray near base; 10 YR 3/1 to 5/1	96.0
Winnetka Member	
Brownish gray clay; many black beds and black mottling; fossiliferous; 10 YR 5/1 to 10 YR 5/3	182.0
Brownish gray clay with many closely spaced thin black layers (varves?); a few fossils; may occupy a channel cut into Sheboygan Member; 10 YR 5/3	243.4
Sheboygan Member	
Brown and reddish brown clay in alternating beds; some dark mottling; 7.5 YR 5/2 and 5 YR 4/4 to 5/4	276.0
South Haven Member	
Reddish gray clay with some faint black beds and faint banding; 5 YR 5/4	344.5

Core 146

Lat. 42°21.8' N, long. 87°20.3' W; water depth 346 feet (105.5 m).

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Dark gray silty clay, soft; trace of fine sand; high water content; 5 Y 3/1	16.5
Lake Forest Member	
Gray silty clay with prominent black beds and black mottling; a few fossils; 10 YR 3/1 to 4/1	106.0
Winnetka Member	
Brownish gray clay; indistinct black beds and mottling; 10 YR 4/3	161.5
Sheboygan Member	
Reddish brown clay; 7.5 YR 4/3	176.5

Sheboygan Member (Continued)	Depth (cm)
Wilmette Bed	
Gray clay, sharp upper contact; 2.5 Y 4/1	186.5
Reddish brown to reddish gray clay in alternating beds; 5 YR 4/3 to 4/4	234.5

Core 147

Lat. 42°21.8' N, long. 87°29.75' W; water depth 270 feet (82.3 m).

Pleistocene Series

Lake Michigan Formation	Depth (cm)
Waukegan Member	
Brown sandy silt, soft, fluid; 10 YR 3/3	9.0
Lake Forest Member	
Dark gray silty clay with prominent black beds and black mottling; fossils; 10 YR 3/1 to 4/1	49.8
Winnetka Member	
Brownish gray clay with a few black beds and some mottling; fossils; some silt; 10 YR 4/2 to 7.5 YR; 4/2 at base	81.5
Sheboygan Member	
Reddish brown clay; some orangish brown; 7.5 YR 4.2 to 5 YR 4/4	124.5
Wilmette Bed	
Dark gray silty clay; some black mottling; 10 YR 4/1 . . .	144.5
Reddish brown to orangish brown clay; 5 YR 4/4 to 4/6	202.4
South Haven Member	
Reddish gray to pink clay with alternating faint layers of gray and pink; 5 YR 5/3	317.0

Core 146

Lat. 42°21.8' N, long. 87°34.5' W; water depth 240 feet (73.2 m).

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Gray sandy clay, very soft and fluid; 10 YR 3/1, 2.5 Y 4/4, 2.5 Y 3/2	10.5
Lake Forest Member	
Dark gray silty clay with prominent black beds and mottling of very dark gray clay; fossils; 10 YR 3/1 to 5/1	74.7
Winnetka Member	
Brownish gray clay with a few dark gray beds and mottling; fossils; 10 YR 5/2	137.7
Sheboygan Member	
Reddish gray to reddish brown clay with a few darker gray beds; fossils; 5 YR 6/2 to 4/2 and 5 YR 4/3	157.5
Equality Formation	
Carmi Member	
Brown silt, fossiliferous; some sand; a few darker beds; 7.5 YR 4/2 to 10 YR 5/2	269.5
Brownish gray sandy silt; 2 beds, each grading downward from coarse silt to fine sand; 10 YR 4/2	293.4
Brown clay-pebble conglomerate; sandy clay matrix; 7.5 YR 5/2 .	317.8
Wedron Formation	
Wadsworth Member	
Brownish gray silty clay till with considerable sand; clay pebbles and rock fragments; 7.5 YR 5/2	325.8

Core 149

Lat. 42°31.7' N, long. 87°08.75' W; water depth 460 feet (140.2 m).

Pleistocene Series

	Depth (cm)
Lake Michigan Formation	
Waukegan Member	
Very dark silty clay with darker mottling, soft, fluid; 2.5 Y 3/2 to 2.5 Y 3/0	11.0

Waukegan Member (Continued)

Depth
(cm)

Dark gray silt with trace of sand, soft; some black mottling . . . 24.5

Lake Forest Member

Dark gray silty clay with prominent black beds and black
mottling; some dark brownish gray layers; 10 YR 5/1 92.5

Winnetka Member

Grayish brown clay with some black beds and black mottling;
gradational base; 10 YR 5/2 128.0

Sheboygan Member

Brown clay; 7.5 YR 5/2 152.6

Wilmette Bed

Gray clay with some black mottling; 5 Y 5/1 162.0

Brown and reddish brown clay; 5 YR 4/3 and 7.5 YR 5/2 176.5

South Haven Member

Reddish gray clay; 5 YR 5/2 182.0

Core 150

Lat. 42°34.2' N, long. 86°57.1' W; water depth 520 feet (158.5 m).

Pleistocene Series

Depth
(cm)

Lake Michigan Formation

Waukegan Member

Very dark gray silty clay, soft, fluid; some black mottling
in lower 10 cm; 5 Y 3/1 80.0

Lake Forest Member

Gray clay with many thin black beds spaced from 1 to 5 mm
apart; 10 YR 5/1 120.0

Winnetka Member

Brownish gray clay with thin, irregularly spaced black beds that
decrease in abundance downward; 10 YR 5/2 to 7.5 YR 5/2 159.0

Grayish brown clay; 2.5 YR 5/2 162.0

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- * 1. Controlled Drilling Program in Northeastern Illinois. 1965.
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